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MEASLES IN CATTLE.

BY

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Chief of the Zoological Division.

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MEASLES IN CATTLE.

By B. H. RANSOM, Ph. D.,
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INTRODUCTION.

The term "measles" as applied in veterinary medicine refers to a condition resulting from the presence of tapeworm cysts or cysticerci in the flesh of food animals. From the standpoint of public health the tapeworm cysts that occur in beef and pork are the most important, as these cysts are the intermediate stages of tapeworms that occur in man. The cysts found in beef when swallowed by man develop into tapeworms of the species known as the unarmed or beef tapeworm (*Tænia saginata*), and those found in pork develop into tapeworms of the species known as the armed or pork tapeworm (*Tænia solium*). Cattle and hogs become infested with the intermediate stage as a result of swallowing the eggs passed in the feces of persons infested with tapeworms. The eggs of the unarmed tapeworm develop into tapeworm cysts only in cattle, and the eggs of the armed tapeworm as a rule develop into tapeworm cysts only in hogs. The eggs of the latter species may, however, develop into cysts in almost any mammal which happens to swallow them, but the hog is by far the most common host of the intermediate stage.

The pork tapeworm is a more dangerous parasite than the beef tapeworm on account of the fact that the intermediate stage may develop in man if the eggs are swallowed, and as the cysts may lodge in vital organs, such as the brain or heart, the consequences are liable to be serious. Fortunately the pork tapeworm and its intermediate stage are very rare in the United States, and this is explained by the fact that in this country raw or imperfectly cooked pork is rarely eaten. Thorough cooking invariably destroys the vitality of tapeworm cysts, and consequently in this country there is little chance that tapeworm cysts in pork will reach a human host alive. Inasmuch as the limited use of raw or imperfectly cooked pork insures the rarity of the pork tapeworm in man, it naturally follows that the intermediate stage in hogs will also be rare, because hogs become infested with the cysts only as a result of swallowing the eggs which occur in the feces of human beings infested with the pork tapeworm.

The beef tapeworm and its cystic stage, unlike the pork tapeworm, are comparatively common in the United States, the explanation

being that raw or rare beef is very frequently eaten. Beef measles at the present time is thus of much greater importance in the United States than pork measles. Although less dangerous than the latter, it is more or less harmful to health, and consequently as a public-health measure the meat of cattle infested with measles must either be excluded from the market, or, in cases of light infestation, after removal of the few cysts found, must be so treated by refrigerating, cooking, or pickling as to render harmless any parasites which may have been overlooked by the meat inspector.

The available figures indicate that nearly 1 per cent of all the cattle slaughtered in the United States at the present time are affected with measles, and this in the aggregate, in addition to exposing to considerable risk of tapeworm infestation the consumer who is not careful to cook thoroughly the beef which he eats, entails a large economic loss as a result of the condemnation of numerous beef carcasses and the more or less expensive restrictions which are placed by the Federal meat-inspection regulations on slightly infested carcasses that may properly be passed for food. Though much of the responsibility for the prevalence of tapeworms in human beings and of the cystic stage of the parasites in cattle rests upon the consumers who do not properly cook the beef which they eat, the lack of proper sanitary precautions in the disposal of human excreta in the localities where cattle are raised and fed is the principal factor in the spread of tapeworm infestation.

LIFE HISTORY.

When a piece of beef containing a living tapeworm cyst is swallowed the immature tapeworm contained in the cyst, consisting of a head and neck, resists the action of the digestive juices and attaches itself to the wall of the small intestine by means of muscular suckers with which the head is supplied. In from two to three months after the ingestion of the tapeworm cyst the tapeworm (Pl. XII) reaches complete maturity and is then several feet in length, consisting of a chain of segments which, very small in the neck region, gradually increase in size posteriorly and reach a length of two-thirds to three-fourths inch and a width of one-sixth to one-third inch at the posterior end of the body. New segments are constantly forming in the neck region, pushing back the segments formed previously, and the full-grown segments at the posterior end of the body are constantly breaking away and passing out of the intestine. The full-grown segments are filled with eggs, averaging in number about 8,000 in each segment. When it is considered that 10 to 12 ripe segments are commonly passed by a tapeworm patient every day and that a tapeworm may live for many years in the intestine of its host, it is evi-

dent that one tapeworm patient may be the source of infection of hundreds or even thousands of cattle with tapeworm cysts. The feces of such a person deposited in a barnyard, feed lot, insanitary surface privy, or in other improper places are liable to contaminate the feed or water supply of cattle by natural drainage or otherwise, with the result that some of the many thousands of tapeworm eggs present in the fecal material ultimately reach their proper intermediate host. When swallowed by cattle the eggs hatch and the tiny embryos migrate from the alimentary canal, get into the circulation, and are carried to various parts of the body, where they settle down in the intermuscular connective tissues. At the end of two to seven months after infestation the embryos have developed into full-grown tapeworm cysts, ready to complete their development into tapeworms when swallowed by man.

The life history of the beef tapeworm thus consists in an alternation between two hosts—man and ox. The ox becomes infested by swallowing the eggs of the tapeworm with feed or water contaminated by the feces of the human host, and man becomes infested by eating the raw or imperfectly cooked flesh of infested cattle.

DESCRIPTION OF THE CYSTICERCI.

The cysticerci of the unarmed tapeworm as seen in beef are small vesicles, usually oval in shape, grayish white in color, varying in size from 5 to 15 millimeters or even more in length, and from 3 to 6 or 8 millimeters in width, but rarely larger than the size of a pea. They are surrounded by an outer cyst of connective tissue which is developed by the host, inside of which is the cysticercus proper consisting of a head or scolex, a neck, and a bladderlike structure within which the head and neck are invaginated after the fashion of a glove finger within a glove. (Fig. 1.) The bladder of the cysticercus contains a fluid, and by pressing on the cysticercus after it has been removed from its outer connective tissue cyst the head and neck may frequently be evaginated, and then become clearly evident. Owing to the transparency of the bladder the whitish scolex and neck may, however, be seen while still invaginated. The head bears at its apex an inconspicuous circular depression beneath which is a circular muscular pad (a rudimentary rostellum) which is surrounded by four oval or nearly circular muscular disks or suckers. When the encysted cysticercus is eaten the outer connective tissue cyst and the bladder are digested, but the scolex and neck resist the action of the digestive juices and become the corresponding structures of the tapeworm.

The histological structure of the cysticercus is similar to that of the adult tapeworm. There is a thin outer cuticle of homogeneous structure, beneath which are very fine contractile fibers running transversely and longitudinally, forming a latticework, the trans-

verse fibers being outermost. A more or less well-defined layer of nucleated cells is found beneath the contractile fibers, and the rest of the body is made up of nucleated parenchymatous tissue in which are imbedded muscle and nerve fibers and in which ramify very thin-walled excretory canals of varying size.

On account of the slight thickness of the wall of the caudal bladder the latticework of the fine transverse and longitudinal subcuticular fibers may, as a rule, if the cysticercus is undegenerated and has not lost its transparency, be readily seen with the microscope, and in this

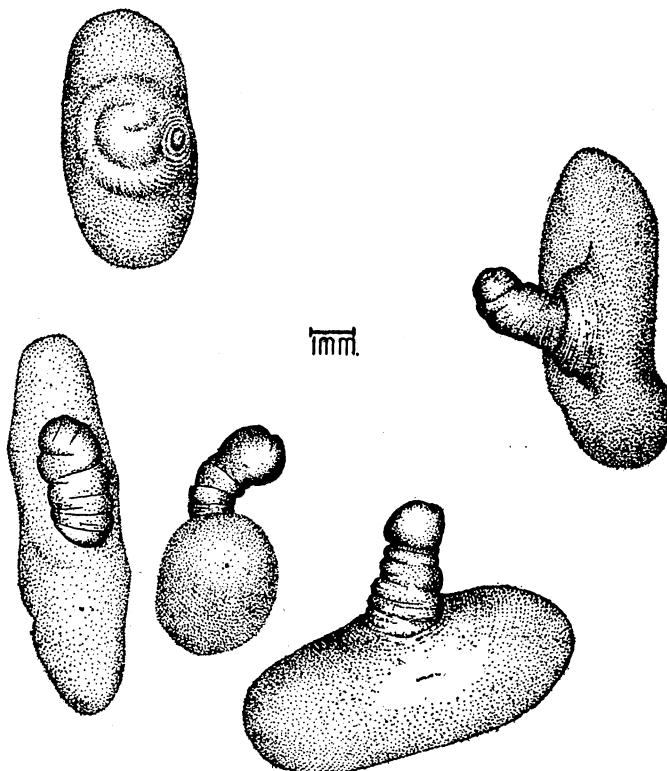


FIG. 1.—Cysticerci removed from cysts. In four of them the head is partially evaginated; in the fifth the head and neck are still retracted within the caudal bladder. (Enlarged. Original.)

part of the cysticercus the irregularly branching excretory canals are also usually evident.

Calcareous corpuscles, which occur in nearly all species of tape-worms, are present, scattered through the parenchyma of the cysticercus, particularly near the surface. They are present in the caudal bladder and head, but are most numerous and of the largest size in the neck. They have a glassy, transparent appearance, and are usually spheroidal, but may be elliptical or kidney shaped. In size they vary

up to about 20 microns in diameter. They are composed largely of a lime salt, but have an organic basis which still persists after treatment with an acid which dissolves out the lime. These calcareous corpuscles when found in the contents of degenerated cysts are a positive proof of the cysticercal nature of the cysts.

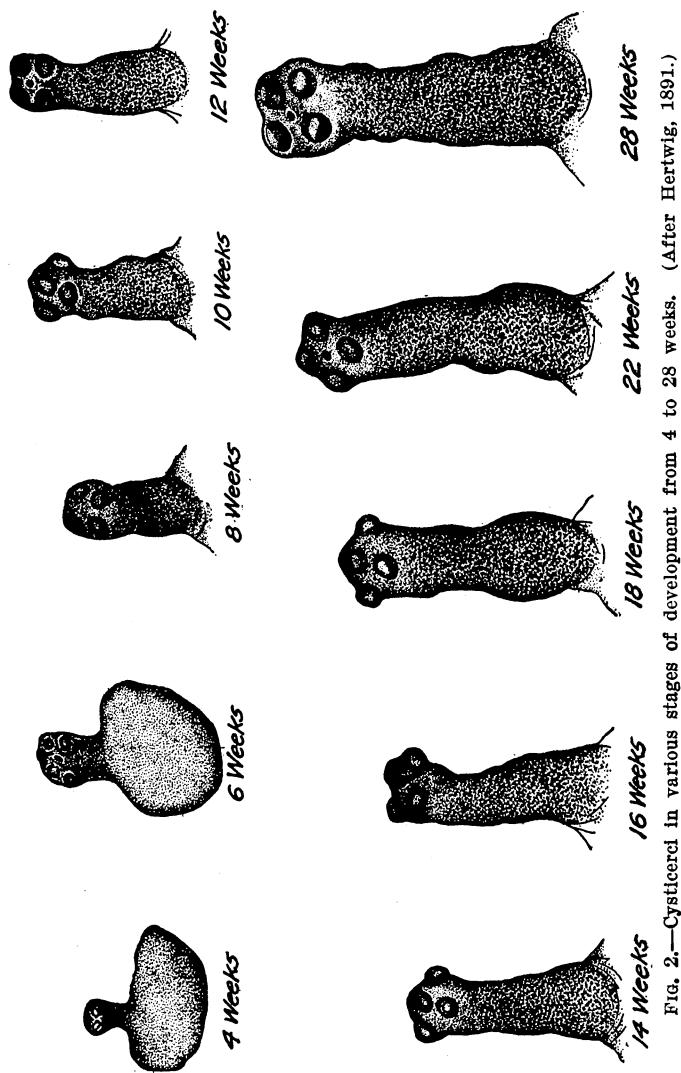
PARTIALLY DEVELOPED AND DEGENERATED CYSTICERCI.

The size and appearance of cysticerci vary with the stage of development. Cysts found by Leuckart 17 to 25 days after experimental infestations measured 2 to 4 millimeters in length and 1.5 to 3 millimeters in breadth. They were whitish in color, as if filled with a chalky or tuberculous material. The envelope of the cysts was composed of connective tissue, and contained an exudate surrounding a clear vesicle, the young bladder worm, 0.4 to 1.7 millimeters in diameter, which protruded when the cyst was cut into. These vesicles were globular, or attenuated at one pole, and in the larger ones the primordium of the head could be seen at the opposite pole. No excretory vessels were found in the bladder worm, but very delicate transverse and longitudinal contractile fibers were present beneath the cuticle in even the smallest cysticerci.

Stroh (1905)¹ has noted that in the case of young cysticerci found in calves of ages varying from 18 days upward the cysts appear as firm, generally elongated nodules of varying size. The cysticerci are either surrounded by a sanguineous serous fluid and then a thick layer of newly formed connective tissue or are associated with a mass of detritus of a more or less caseous consistency, yellow, green, or brown in color, largely composed of blood elements. In the latter instance the mass of detritus and the cysticercus are surrounded by a well-developed cyst wall, and the cysticercus is commonly found near one side of the cyst between its wall and the caseous mass. In such cases, in spite of the caseous nature of the contents of the cyst, the cysticercus itself may show no evidence of any degeneration process.

Hertwig (1891b) by a series of experiments found that the cysticercus becomes fully developed in 18 weeks after infestation. The following table from Hertwig gives the sizes of the cysticerci at different ages from 4 to 28 weeks, and the appearances are shown in figure 2.

¹ References to literature may be found in the Index-Catalogue of Medical and Veterinary Zoology, Bureau of Animal Industry Bulletin 39.



Sizes of cysticerci at various ages. (From Hertwig.)

Age (in weeks).	Entire cyst.	Cysticercus without connective tissue cyst.	Scolex.	
			Natural size.	Stretched.
4.....	4.0 by 3.5 mm.....	2.25 by 2.25 mm.....	0.5 by 0.5 mm.....	0.7 mm. long.
6.....	4.2 by 3.5 mm.....	3 by 2.5 mm.....	1 by 1 mm.....	1.3 mm. long.
8.....	4.5 by 3.5 mm.....	3.25 by 2.75 mm.....	1.5 by 1 mm.....	2.9 mm. long.
10.....	5 by 3.75-4 mm.....	3.5 by 3.5 mm.....	1.75 by 1 mm.....	3.3 mm. long.
12.....	5-6 by 3.5-4 mm.....	4 by 4 mm.....	1.8 by 1 mm.....	3.5 mm. long.
14.....	6 by 4.5 mm.....	5 by 4.5 mm.....	2 by 1 mm.....	4 mm. long.
16.....	do.....	do.....	do.....	4.25 mm. long.
18.....	6.25-7 by 4.5 mm.....	6 by 4 mm.....	2 by 1.25 mm.....	5 mm. long.
22.....	6.5-8 by 4.5 mm.....	6 by 4.5 mm.....	2.25 by 1.75 mm.....	5.5-6.25 mm. long.
28.....	7.5-9 by 5.5 mm.....	7 by 5 mm.....	2.5 by 2 mm.....	7 mm. long.

FIG. 2.—Cysticerci in various stages of development from 4 to 28 weeks. (After Hertwig, 1891.)

According to Hertwig, calcareous corpuscles are not present in any considerable number until the cysticercus is 4 weeks old.

Degeneration of cysticerci from causes other than inflammatory processes is said by Ostertag to occur commonly in the case of old, fully developed cysts, but may also occur in cysts at younger stages of development. Hertwig has noted in his experiments that degenerated cysts were to be found as early as four weeks after infestation.

Dead cysticerci in course of degeneration, according to Hertwig, exhibit a cloudiness and thickening of the cyst wall and a cloudiness of the fluid of the cysticercus, which gradually becomes thicker and in which lime salts become deposited, while the originally bright, white color of the neck and scolex of the cysticercus changes to a greenish yellow. In later stages of degeneration the cyst and its contents become semisolid, the contents presenting the appearance of a crumbling, mortarlike mass of a yellowish, sometimes a greenish, color. In some cases, as noted by Kallmann (1888a), in which caseation of the cyst has become well advanced, the grosser morphological structure of the cysticercus still persists.

Ostertag describes the noninflammatory degeneration of cysticerci as beginning with a coagulation necrosis which appears in the caudal vesicle and becomes conspicuous as a caseation, which gradually passes into a calcification. The enveloping cyst of the parasite usually remains intact during this process. Caseation apparently does not always begin with the cysticercus itself as described by Ostertag, inasmuch as cysts may be found with caseous contents in which intact cysticerci are present. In these cases the cysticercus is frequently found at the surface of the caseous mass between it and the cyst wall. Degeneration processes may involve all of the cysticerci in a given animal, but do not always do so. Degenerated cysts in certain parts of the body may be associated with cysts in other parts or even in the same organ which have undergone no degeneration. This is no doubt often the result of more than one infestation, but the presence of degenerated and undegenerated cysts in the same animal can not in all cases be explained in this way.

Cysticerci located in the heart are particularly likely to undergo early degeneration. Occasionally cases are seen in which both undegenerated and degenerated cysts occur together in the heart, and it is quite usual to find degenerated cysticerci in the heart associated with living cysticerci in other portions of the body, particularly in the muscles of mastication. On the other hand, when only degenerated cysticerci are found in the muscles of mastication it is rarely the case that other muscles will contain living parasites.

Ostertag mentions the rather frequent occurrence in beef of cysts varying from the size of an oat grain up to that of a pea, with thick, tough, opaque walls, and with only a small cysticercus. Such cases

he considers as resulting from an unusually strong reaction of the surrounding tissue after the penetration of the tapeworm embryos. The cysticercus except for its small size may be normal or may be attached to the wall of the cyst by a fibrinous exudate resulting from an inflammation of the inner membrane of the cyst. Similar inflammatory processes, according to Ostertag, may also appear in the case of normally developed cysticerci during various stages of development, and may lead to the death of the parasites. Suppuration may occur as the result of the introduction of bacteria which have been carried along by the wandering embryos, or as the result of the excretion of bacteria from the blood into the cysts.

OCCURRENCE OF BEEF MEASLES.

As already noted, beef measles occurs in the United States in nearly 1 per cent of all cattle slaughtered. Out of 332,446 cattle slaughtered during one month in 57 establishments under Federal inspection, 2,445 were infested with measles, slightly over three-fourths of 1 per cent. In certain European countries measles have been found in as high as 4 per cent of the cattle slaughtered. In the German Empire the percentage of infestation at the present time is said to be somewhat less than 1 per cent.

It has been noted by several observers that bulls and steers show a somewhat higher percentage of infestation than cows, and this is explained by Ostertag by the fact that male cattle are usually slaughtered at a younger age than cows, at which time infestation with measles usually occurs, and also by the fact that measles may in the course of time become degenerated and entirely absorbed, so that old animals which have become infested during their youth may, when slaughtered, show no apparent evidence of the former infestation.

Suckling calves are rarely found infested with measles, but otherwise, as already intimated, measles are less likely to be found in old cattle than in young animals. It is a general rule based upon observations on many kinds of tapeworms that young animals are more liable to infestation with larval tapeworms than old animals, possibly because their tissues offer less resistance to the migration of the embryos and the growth of the cysticerci.

LOCATION IN THE BODY.

Infestation of cattle with measles is usually slight. The muscles of mastication, according to the experience of meat inspectors in Germany, are by far the most frequently affected. In order of frequency, the heart follows the muscles of mastication, but is much less commonly affected; next in order comes the tongue. Other favorite locations

are the cervical, thoracic, and intercostal muscles and the muscular portion of the diaphragm. The round or rump is said to be not infrequently infested. According to experience in this country the order of frequency is heart, muscles of mastication, diaphragm, and tongue.

Beef measles are rarely found in locations other than the voluntary muscles and heart, but have been recorded as occurring in the lungs, pleura, liver, brain, lymph glands, thymus, supporting cartilage of the nictitating membrane, esophagus, fat, and kidney.

Investigations conducted by Dr. W. N. Neil, of this bureau, show that in 334 cases of infestation the frequency of infestation in various parts of the carcass was as follows:

Head muscles.....	224
Heart.....	225
Diaphragm.....	71
Tongue.....	52
Esophagus.....	2

Muscles of the following market cuts:

Chuck.....	42
Loin.....	39
Round.....	13
Rump.....	6
Shank.....	4
Plate.....	4
Brisket.....	3
Rib.....	2

In 108 cases the heart was not involved, and in 109 cases the head muscles showed no infestation. The head muscles and heart were both involved in 116 cases, and in 117 cases only a single cyst was found.

The results of a more extensive investigation by bureau inspectors are shown in the following statement which has been compiled from the records of the number and distribution of the cysts found in each retained carcass. In making the examination, the heart, tongue, diaphragm, and muscles of mastication were cut into slices and the remainder of the carcass was divided into 24 market cuts, and all muscular surfaces thus exposed were carefully examined for cysts.

Tabular statement of the results of an investigation concerning beef measles conducted by inspectors of the Bureau of Animal Industry at 9 meat-inspection stations (57 establishments) during the period of a month.

	Number.	Per cent.
Number of cattle slaughtered (not including calves).....	332,446	-----
Total retained for measles (including a few calves).....	2,445	0.76
Heart involved.....	1,700	39.5
Muscles of mastication involved.....	1,148	46.9
External muscles of mastication involved.....	1,090	44.6

Tabular statement of the results of an investigation concerning beef measles conducted by inspectors of the Bureau of Animal Industry, etc.—Continued.

	Number.	Per cent.
Internal muscles of mastication involved.....	212	8.6
Both external and internal muscles of mastication involved.....	154	6.3
Diaphragm involved.....	148	6.1
Tongue involved.....	74	3
Various other muscles involved.....	193	7.9
Heart involved without infestation of muscles of mastication.....	1,279	52.3
Muscles of mastication involved without infestation of heart.....	727	29.7
Heart only involved.....	1,164	47.6
Muscles of mastication only involved.....	669	27.3
External muscles of mastication only involved.....	614	25.1
Internal muscles of mastication only involved (these muscles regularly inspected at only a few establishments).....	33	1.3
Both external and internal muscles of mastication, but no other parts involved.....	22	.9
Infestation limited to 1 live cyst in heart.....	63	2.5
Infestation limited to 1 caseous cyst in heart.....	155	6.3
Infestation limited to 1 calcified cyst in heart.....	616	25.2
Infestation limited to 1 live cyst in muscles of mastication.....	309	12.6
Infestation limited to 1 caseous cyst in muscles of mastication.....	89	3.6
Infestation limited to 1 calcified cyst in muscles of mastication.....	184	7.5

The following tables taken from Hertwig (1890) show the distribution of the cysticerci in 389 cases of measles found in the Berlin abattoir during the period of a year (1889–90) :

In the masticatory muscles.....	316
In the masticatory muscles and heart.....	39
In the masticatory muscles and cervical muscles.....	1
In the masticatory muscles and the tongue.....	4
In the cervical muscles.....	1
In the cervical muscles and tongue.....	1
In the tongue.....	2
In the tongue and heart.....	2
In the thoracic muscles and tongue.....	1
In the whole musculature.....	22

According to these figures the cysticerci, except in 22 cases in which they were distributed throughout the body, were located—

In the masticatory muscles.....	360
In the heart.....	41
In the tongue.....	10
In the cervical muscles.....	3
In the thoracic muscles.....	1

It is stated by Reissmann (1901) that 813 cattle infested with measles were passed upon at the Berlin abattoir during the fiscal year 1899. Besides these there were 187 cases in which the cysticerci were calcified. The latter are not included in the following statistics of distribution of the cysts in the carcass:

Muscles of mastication only-----	767
Inner muscles of mastication only-----	266
Outer muscles of mastication only-----	488
Heart only -----	14
Muscles of mastication and heart-----	9
Heart and tongue-----	1
Muscles of mastication, heart, and tongue-----	6
Muscles of mastication and tongue-----	3
Muscles of mastication, heart, and pectoral muscles-----	1
Muscles of mastication, heart, and diaphragm-----	1
Heart, muscles of shoulder, and abdominal muscles-----	1
In the whole musculature-----	10
Monocystic carcasses-----	754

A summary of the statistics which have been given of meat inspection at Berlin for the years 1889 to 1899, excluding the fiscal year 1891-92, for which the records are very incomplete, shows that out of 4,539 cases of beef measles the muscles of mastication only were infested in 4,159 cases (over 91 per cent), and that these muscles were involved in 4,428 cases (in which are included certain cases in which it was not definitely stated that these muscles were infested, namely, cases noted as having the entire musculature infested); over 97 per cent of all cases therefore showing measles located in the muscles of mastication.

The difference in the distribution of the parasites as noted in Germany and in this country is difficult to explain, but may be the result of different methods of inspection. For example, it is possible that in Germany a more careful examination is made of the muscles of mastication than in this country, and on the other hand that more attention is given to heart inspection in the United States than in Germany. Another plausible explanation which would account in part for the discrepancy between the German and American figures is that the German statistics as to the distribution of the cysts in the carcass exclude numerous cases in which only a few degenerated cysts are found; and the heart being a common location of degenerated cysts, it is reasonable to suppose that many if not practically all of the excluded cases are cases in which the heart is involved, and consequently that if these cases were included in the statistics the percentage of heart infestation would be much higher.

METHODS OF INSPECTION FOR DISCOVERING CYSTICERCI.

In inspecting beef carcasses for the presence of cysticerci it follows from what has already been stated relative to the frequency of the parasites in different parts of the body that the muscles of mastication and the heart should receive special attention, in addition to which, however, other muscular parts which are rendered visible and readily accessible in the operation of slaughtering should also be examined.

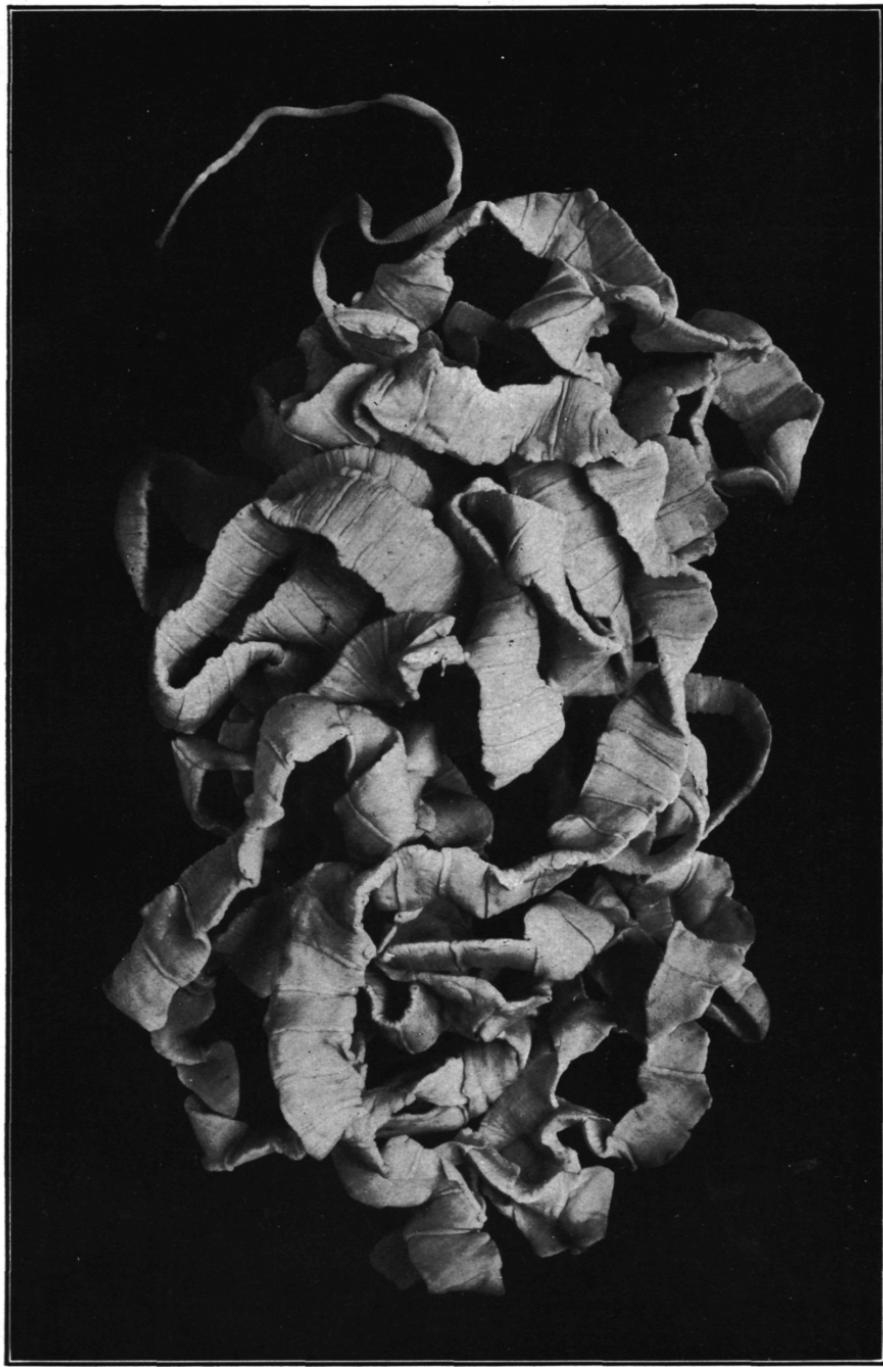
Where practicable the meat and the tongue should be removed from the head prior to inspection, and a careful examination made of the muscles of mastication, which should be sliced so as to expose as much of the muscular tissue as possible. At the same time the visible portions of the tongue and attached muscles should be inspected. If it is not practicable to remove the head meat and the tongue at this stage, the tongue should be so loosened as to expose the internal muscles of mastication. These muscles and the external muscles may then be inspected *in situ*. Incisions should be made in the muscles of mastication, cutting parallel with the lateral surfaces of the lower jaw bone. In the case of the masseter muscle the cut should be continued far enough to leave the separated portion of the muscle attached only near the orbital border. By reflecting this piece a clear view may be had of the cut surfaces of the muscle. In slicing the masseter the section should pass through the muscle midway between the superficial and intermediate fasciæ, or else through the deep portion of the muscle beneath the intermediate fascia. The latter cut makes the subsequent removal of the cheek meat from the bone more difficult, and hence in regular routine inspection the former cut is preferable (Pls. XIII-XV).¹

In inspecting the heart the pericardium should be opened and the surface of the heart examined. Both ventricles should be opened with a lengthwise incision and an examination made of the cut surfaces and of the interior. In order to avoid soiling the surface of the heart unduly with blood, the incision should be made with the left ventricle uppermost. The wall on the lower side of the heart as held in this position need not be cut through, and if left intact will serve as a hinge upon which the heart is opened for examination.

That a mere superficial examination of the heart is insufficient is shown by a report from Dr. B. P. Wende of this bureau, who had an examination made of 4,324 hearts, none of which showed external evidence of infestation. Ninety-three of these hearts when cut into pieces were found to contain measles cysts. Dr. A. O. Lundell and Dr. J. S. Kelly of this bureau have also called attention to the occurrence of measles deep seated in the heart when none were evident superficially.

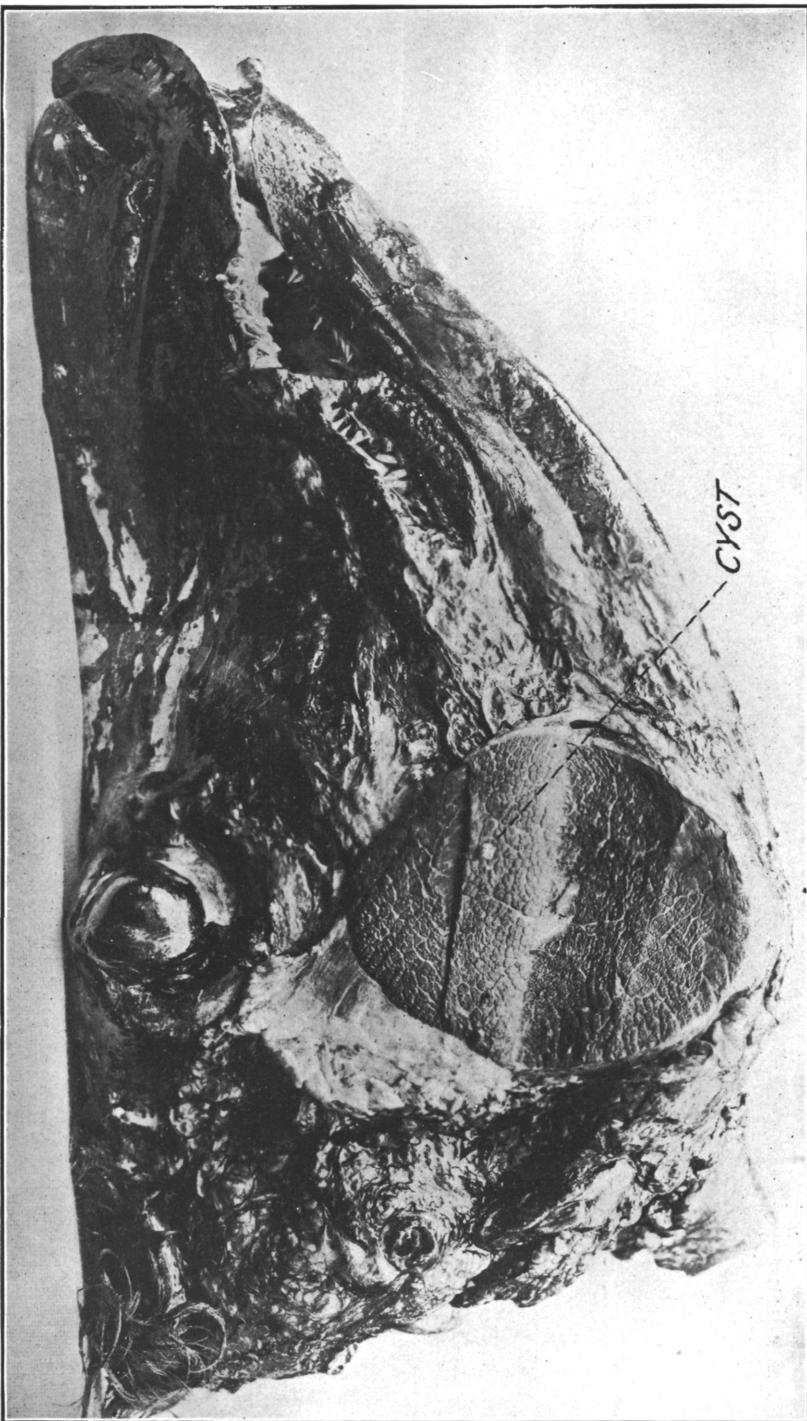
In the case of calves less than 6 weeks old it is generally considered unnecessary to make a special inspection for measles, and the German regulations provide that such inspection may be omitted. In calves of this age any cysticerci present will be small, only partially developed, and incapable of developing into tapeworms; and it is very exceptional that any cysticerci will be present in such young animals, as they do not have the same opportunities of becoming infested as

¹ Plates XIII to XVI are from photographs by Drs. Thomas White and A. English, of the meat-inspection force of the Bureau of Animal Industry at South Omaha, Nebr.



MATURE TAPEWORM (*TÆNIA SAGINATA*).

The tiny head and slender anterior portion of the worm are seen in the upper left-hand portion of the picture. (Natural size. Original.)

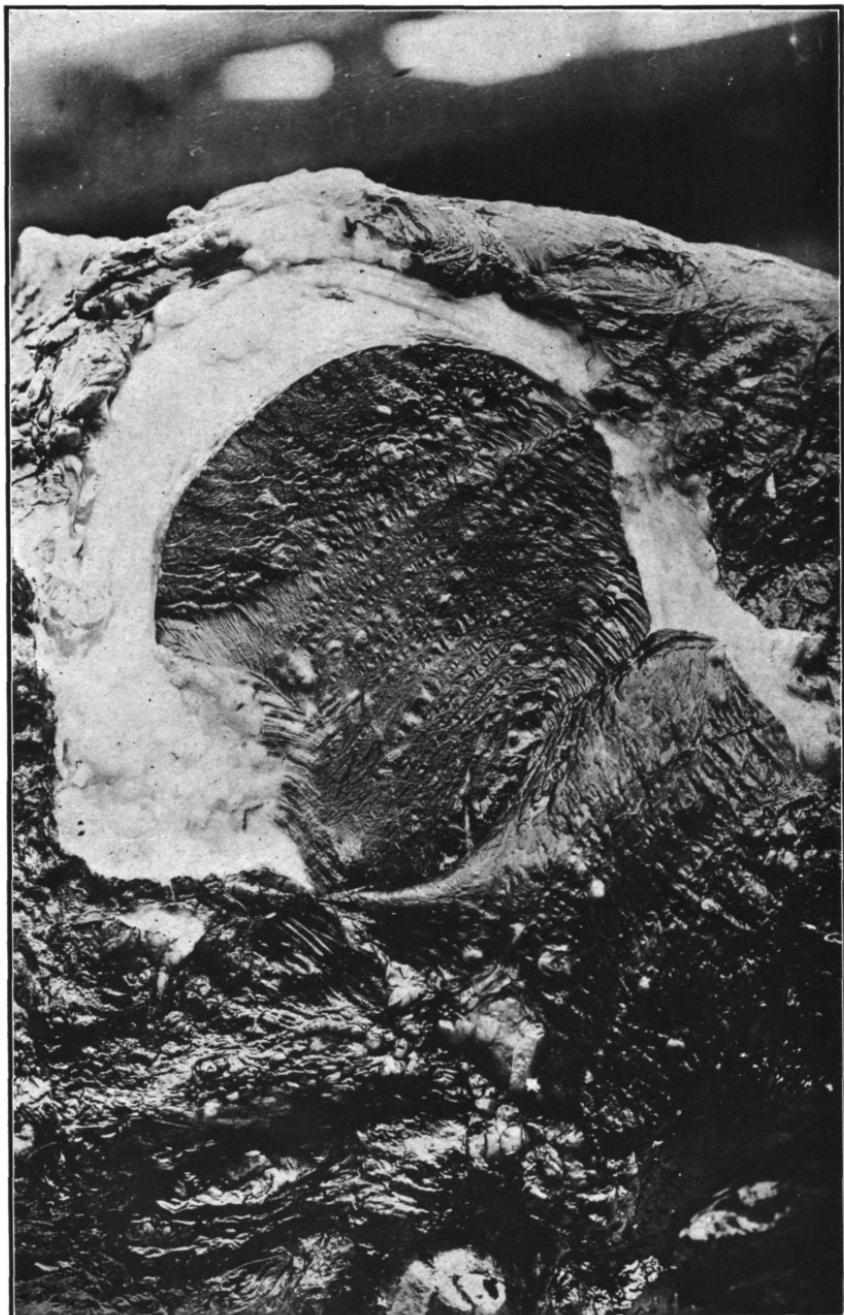


COW'S HEAD, WITH CUT IN MASSETER MUSCLE, SHOWING LIVE CYST OF CYSTICERCUS BOVIS.

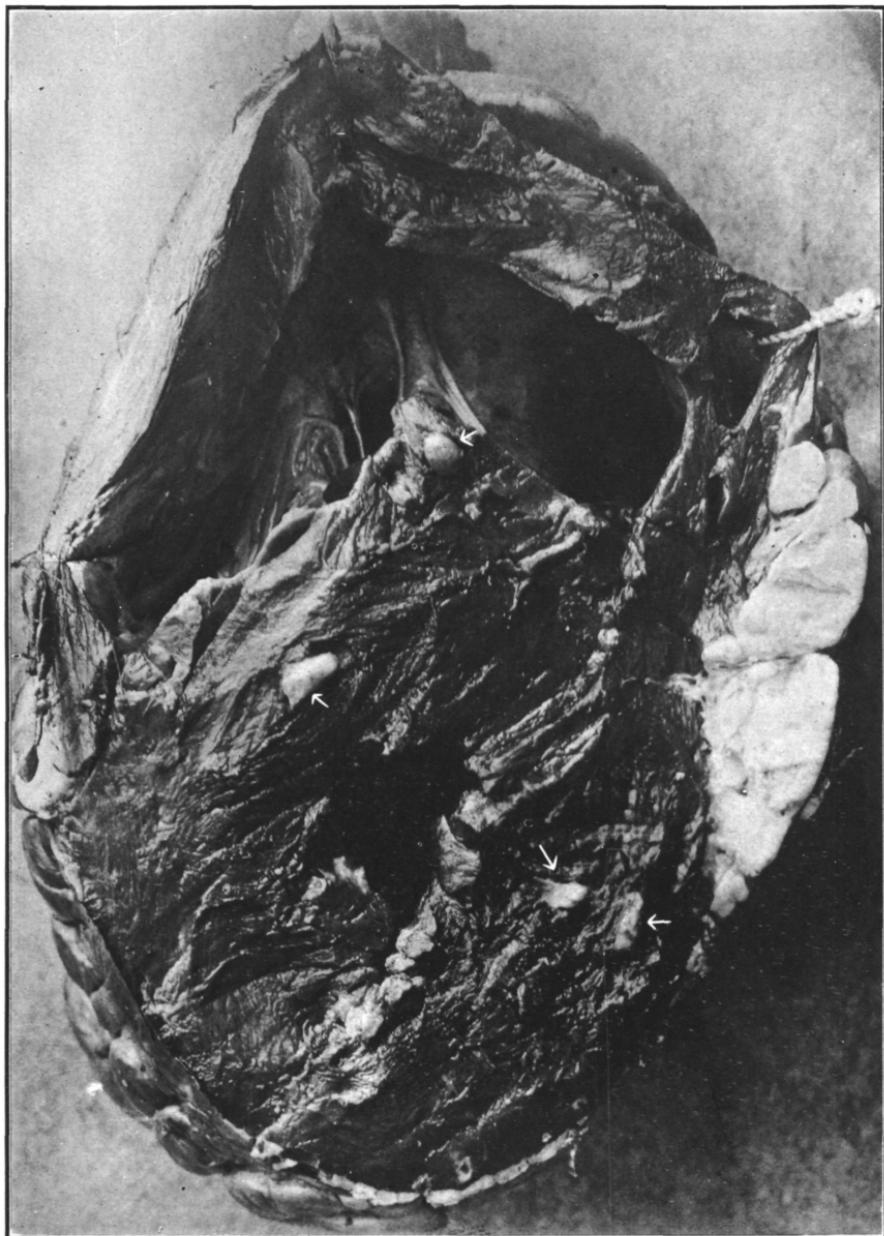


LIVE CYST IN MASSETER MUSCLE OF COW'S HEAD.

(Slightly enlarged, from same specimen shown in Pl. XIII.)



NUMEROUS CALCIFIED CYSTS IN MASSETER MUSCLE OF COW'S HEAD.
(Slightly reduced.)



FOUR LIVE CYSTS IN BEEF HEART.

Arrows indicate locations of cysts.

older animals which are past the sucking stage. In cases which have been traced it has been found that the calves were pail fed and that the attendants were infested with tapeworms. The transfer of eggs from the attendants' hands soiled with fecal matter to the mouth of the calf was a very natural result under the circumstances.

DIAGNOSIS.

Fully developed, undegenerated cysts are readily recognizable as such. The bladderworm when freed from its outer connective tissue cyst presents characters which clearly demonstrate its nature (fig. 1). The thin-walled caudal bladder and the invaginated head and neck which may sometimes be caused to protrude by pressure between the fingers are plainly evident features visible to the naked eye. In dead cysticerci it is usual to find the head partially or completely evaginated. Microscopically the numerous calcareous corpuscles of the neck and the four suckers of the head may be seen. *Cysticercus tenuicollis*, the larval stage of the marginate tapeworm of the dog, which occurs in cattle, sheep, hogs, and other animals, may be distinguished from *Cysticercus bovis*, the beef measles bladderworm, by the fact that it does not occur in the striated musculature but only under the serous membranes or, in young stages, in the liver. Furthermore, *Cysticercus tenuicollis* possesses a crown of hooks on the head, whereas *Cysticercus bovis* is without hooks.

Echinococcus cysts, which rarely occur in the musculature, may sometimes, when of small size, be confused with beef measles bladderworms, but are distinguishable from the latter by the fact that they do not possess a simple scolex, and are either without heads or contain brood capsules inclosing several or many heads, which are smaller and otherwise quite different from that of *Cysticercus bovis*. Microscopically the cuticula of an echinococcus is seen to be thick and laminate. This lamination is usually evident in the cuticle of degenerated echinococci as well as in those which have undergone no degeneration, and is a character not seen in the thin homogeneous cuticula of cysticerci.

In the case of partially developed or degenerated cysticerci a definite diagnosis of their nature is frequently difficult. The former, however, may be identified as cysticerci if in the exudate contained in the surrounding envelope of newly formed connective tissue there is found a small, clear vesicle, in whose wall is a latticework of very delicate transverse fibers and longitudinal fibers, visible under a high power of the microscope. The exudate may be a more or less sanguineous fluid, or caseous in consistency, and green, yellow, or brown in color.

In the case of degenerated cysticerci in which the process of degeneration has not gone beyond caseation, the parasites may still retain

their characteristic form and structure, but usually it is not possible to demonstrate the caudal bladder, the scolex with its suckers, and other grosser characters intact, and this is especially true after calcification has set in. Under such circumstances a provisional diagnosis of cysticercus may be made on the ground that connective tissue cysts of the size of a pea or small hazelnut (usually the maximum size of *Cysticercus bovis* cysts) or smaller, with caseous or calcified contents, located in the voluntary muscles or heart of cattle, can scarcely be anything but cysts of *Cysticercus bovis*. The finding of calcareous corpuscles in the contents of such cysts is conclusive evidence that they are cysticercus cysts.

Sarcocystis cysts (*Sarcocystis blanchardi*) which occasionally occur in the esophagus of cattle might carelessly be mistaken for cysticerci, but their appearance is characteristically different and their contents consist largely of very numerous falciform spores about 15 microns long. These cysts when occurring in locations other than the esophagus are usually almost microscopic in size and hence not likely to be confused with cysticerci.

Actinomycotic tubercles occurring in the tongue may in certain cases be confused with cysticerci, but may be differentiated from the latter by the following characters. Within the connective tissue wall which delimits the tubercles from the surrounding tissue may be seen small pale-yellow masses, which on microscopic examination are found to be made up of the radially arranged mycelia of the ray fungus.

Kieckhäuser (1896) has described a case of lymph cysts resembling cysticerci. These cysts located in the hyo-glossus muscle varied in size from that of peas to hazelnuts. Their nature, however, was immediately apparent upon incision. Dr. U. G. Houck of this bureau has also called attention to the not uncommon occurrence of lymph cysts on the fasciae of the masseter muscles. (See Pl. XVIII.)

VITALITY OF CYSTICERCI.

Beef cysticerci, as determined by various observers, die when exposed for 5 minutes to a temperature of 44° to 60° C. (112° to 140° F.). In practice, however, to insure the death of the cysticerci it is necessary to use higher temperatures and to apply the heat for a longer time, for the reason that heat does not penetrate readily into large pieces of meat. For the sake of safety cooking should be continued until the meat is well done and presents a uniform gray appearance when cut across. This change of appearance does not occur until the temperature has reached 60° to 70° C. (140° to 156° F.), and it thus affords a means of determining whether the cooking has been sufficient to kill any cysticerci which may be present.

In salt solutions of the strength ordinarily used in pickling, isolated cysticerci die in 24 hours. Owing to the uncertainty as to the length of time required for the thorough penetration of pickling solutions into pieces of meat, it seems unsafe to depend upon pickling as a means of hastening the death of cysticerci, and as a rule infested beef placed in pickle should not be considered safe to eat until 21 days have elapsed.

Decomposition of the meat does not necessarily destroy the vitality of cysticerci, as they have been found still alive in badly decomposed meat.

Cysticerci die naturally within a certain time after the death of the host, and in some cases may all be dead within 2 weeks. Investigations by various authors have shown that 3 weeks may be accepted as a safe limit within which all cysticerci will have perished.

Freezing destroys the vitality of beef cysticerci rather quickly, and it seems safe to assume that all cysticerci will be dead if meat in pieces the size of regular market cuts is solidly frozen and kept at a temperature of not more than 12° F. for 6 days. In the experiments which have been made with reference to freezing, rather small pieces of meat have been used. It is well known that small pieces of meat will freeze much more rapidly than large pieces, and it is also known that various organisms which are unable to withstand a rapid lowering of temperature to below the freezing point commonly survive freezing when the temperature is lowered very gradually. It is, hence, uncertain whether freezing, which has been found to destroy the vitality of cysticerci in small pieces of beef in a few days' time, would prove equally efficacious in the case of large pieces. Accordingly, in the case of large pieces, such as quarters and sides of beef, it is not justifiable, on the basis of our present knowledge, to assume that all cysticerci will be dead in less than 21 days.

DISPOSAL OF BEEF INFESTED WITH CYSTICERCI.

Since beef cysticerci when taken into the alimentary canal of human beings develop into tapeworms that have more or less injurious effects upon their hosts, creating digestive disturbances and discomfort, withdrawing nutriment, and sometimes giving rise to serious nervous affections, it is evident that beef infested with living cysticerci is a harmful article of food. If the carcass is heavily infested, showing evidence of a general distribution of cysticerci in large numbers throughout the musculature, or, without reference to the number of parasites, if the flesh is watery or discolored as a result of the parasitic invasion, it should be condemned.

If the infestation is moderate, the carcass may be rendered into tallow. In Germany, which has a "Freibank" system, moderately infested carcasses are allowed to pass for food provided they are cut

into pieces of about $5\frac{1}{2}$ pounds each, and provided they are refrigerated for 3 weeks or are cooked or pickled. Such pieces, however, must either be placed on the Freibank or sold under declaration.

Slightly infested carcasses may be passed for food provided they are refrigerated for 3 weeks; and there is also no objection from a sanitary standpoint to passing such carcasses after they have been pickled for 3 weeks or after the meat has been cooked. Refrigeration, however, furnishes the most satisfactory means of safeguarding against slightly infested carcasses, as there is less depreciation in their value than when they are cooked or pickled. The fat may be passed for food without refrigerating provided it is melted at not less than 140° F., which is a sufficiently high temperature to destroy the vitality of any cysts which might have been overlooked.

ERADICATION OF MEASLES.

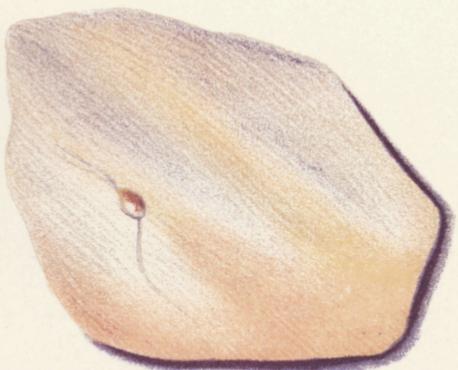
An efficient meat inspection is an important means of eradicating the tapeworms of man and their intermediate stages in cattle and hogs. By excluding from human consumption all meat infested with cysticerci these tapeworms (*Taenia saginata* and *T. solium*) would soon become extinct in the human race, and in the absence of the tapeworm stage there would of course be no further infestation of cattle and hogs. There is, however, no practical method of meat inspection which would absolutely insure the freedom of all inspected meats from cysticerci. Moreover, in the United States meats intended solely for local consumption within the boundaries of the State in which the animals from which they are obtained are slaughtered are not subject to inspection by Federal authorities, and hence, as inspection is rarely conducted by local authorities, much uninspected meat is consumed. Under these conditions there is a large loophole through which measly beef and pork may find their way to the consumer. Furthermore, no system of meat inspection could be expected to extend to meats killed for home consumption on farms and ranches, and it is in these places that the occurrence of tapeworms in human beings is of the greatest importance, for it is there that the passage of the parasites from the human host to cattle and hogs is most likely to occur.

Consequently, in order to reduce to a minimum the chances of becoming infested with tapeworms, beef or pork should not be eaten unless thoroughly cooked. Even with this precaution it is conceivable that infection might occur; for example, a careless cook might by using the same knife for cutting raw meat and bread transfer a cysticercus from the meat to the bread, with which it might be eaten unnoticed.

Perhaps the most important prophylactic measure of all is the proper disposal of human feces. The common carelessness in this



PORTION OF HEART OF STEER INFESTED WITH CYSTICERCUS.



LYMPH CYSTS ON SUPERFICIAL FASCIA OF MASSETER MUSCLES OF CATTLE.

matter results in the spread of tapeworm infection from human beings to animals, as well as in the spread of a number of diseases of man, such as hookworm disease and typhoid fever.

Every human being infested with a tapeworm is a peripatetic center of infection, and inasmuch as each gravid segment of a tapeworm contains several thousand eggs, and as several segments may become gravid and be expelled every day during a period which may extend over several years, it may easily happen that hundreds of cattle or hogs may become infested from a single tapeworm patient, if this person lives in a rural district where live stock are raised and kept. Human excreta should therefore not be placed where live stock can have access to them, or where there is any possibility of resultant contamination of feed or water. It is very unhygienic for human beings to defecate in buildings, yards, or pastures occupied by live stock; and if this is done by persons infested with tapeworms, the infestation of cattle (or hogs, in the case of the armed tapeworm) is almost certain to result. The question of the proper disposal of human dejecta on the farm is fully discussed in Farmers' Bulletin 463, which may be obtained free on application to the Secretary of Agriculture.

A person knowing himself to be infested with a tapeworm should of course get rid of the parasite as soon as possible. By so doing he will add to his own health and comfort and will avoid the risk of spreading infection to live stock and indirectly to other human beings. Treatment, however, should be undertaken only under the care of a physician, as tapeworm remedies are liable to be dangerous or ineffectual if not properly used.

From the foregoing it is evident that the prevention of tapeworm infection in human beings and of measles in cattle and hogs is comparatively simple and may be accomplished by the following means:

1. An efficient meat inspection.
2. Proper cooking of meat before it is eaten, particularly if there is any doubt of its freedom from infestation with measles.
3. Disposal of human feces so that live stock can not have access to them and so that there is no possibility of contaminating the feed or water supply of live stock.

